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Empirical similarity of responses of two random samples of North Carolina swine producers to a management questionnaire used in the US National Swine Survey

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Abstract

The United States Department of Agriculture's (USDA) National Animal Health Monitoring System (NAHMS) National Swine Survey (NSS), implemented in 1990, represents the first national effort to collect on-farm data using a statistically valid method. The purpose of the North Carolina Swine Survey (NCSS) was to evaluate the reliability of the NSS by assessing the similarity of responses between the North Carolina portion of the NSS and the NCSS using identical questions. Responses from the North Carolina portion of the NSS ($n=40$ farms) and from the NCSS ($n=139$ farms) were compared for a subset of the first three questionnaires used in the NSS. Chi-square analysis was used to test for significant differences between estimated proportions from the two studies. Plots of component chi-square values and frequency distribution of differences between point estimates were used to evaluate the similarity between sections of the questionnaires. Approximately 75% of the 446 point estimates were within 15% of each other. The majority of significant discrepancies occurred for the biosecurity section of the second questionnaire, specifically for response categories of 'No' and 'N/A' (not applicable). Percent of farms responding 'Yes' showed greater comparability between the two studies. While most questions from the first and third questionnaires (General Swine Farm Report and the Facili-

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ties and Feed Report) proved to be similar, questions regarding disease problems, vaccination and preventive practices were less similar between the two studies.

Keywords: Pig; Health monitoring; NAHMS

1. Introduction

The need for reliable information on the mortality and morbidity of animal diseases has long been recognized. In 1920, the US Livestock Sanitary Association (USLSA) adopted resolutions for each State "to gather reliable information concerning the health of livestock" (Clarkson, 1954). While several State reporting systems were in place, they were inconsistent, non-additive, and generally unreliable. Only with reliable statistics "can the full resources of modern veterinary science be brought effectively and efficiently to bear on the animal disease problems of the nation" (Hutton, 1974).

Considering the inadequacies of past reporting systems, the success and usefulness of the newly formed National Animal Disease Surveillance system was dependent upon the collection of high quality and unbiased data on animal health (Poppensiek, 1985; Hueston, 1988). After several years of pilot projects, developing various methods of sampling and data collection, the National Animal Health Monitoring System (NAHMS) set out to implement the first national survey, focusing on the farrowing period of swine operations. Data collected would be used to produce the first national estimates on the prevalence and incidence of disease conditions, the cost of certain disease and production, as well as the frequency of certain management practices and farm characteristics. The comprehensive nature of the study would also allow for the collection of epidemiological intelligence needed for studying multifactorial, endemic diseases of primary importance to today's swine production operations (Schwabe et al., 1977). The specific uses and beneficiaries of the NAHMS have been detailed elsewhere (Dahl, 1985; Hoffis, 1985; King, 1985; Mulhern, 1985; Poppensiek, 1985).

The usefulness and success of the National Swine Survey (NSS) is contingent upon the statistical accuracy of the estimated parameters relating to animal health. Reliability addresses the question of whether the data are sound and dependable. It specifically refers to the degree in which the results obtained in the NSS can be replicated (Last, 1988). The purpose of this study was to evaluate the reliability of the NSS. Therefore, portions of the NSS were replicated in North Carolina, keeping as many conditions as possible equal. Point estimates from the North Carolina portion of the NSS (NCNSS) were compared with the North Carolina Swine Survey (NCSS) and evaluated for similarity.

2. Methods

2.1. National Swine Survey

The NAHMS NSS survey took place in 18 States and covered 84% of the nation's swine producers and 95% of hogs. The details of the planning, design, and administration of the NSS have been described elsewhere (NAHMS, 1989a, 1992). National Agriculture Statistical Service (NASS) used stratified sampling from both area and list frames to select 186 North Carolina producers for the first phase of the NSS. Initial contacts were made by NASS enumerators who administered the General Swine Farm Report (GSFR) on 93 producers in North Carolina. Consenting farms were followed up by APHIS Veterinary Medical Officers (VMOs) who presented an overview of the 3 month long study and its benefits. Of the 93 producers turned over to Veterinary Services (VS), 81 were eligible to participate in the 3 month study with 40 producers actually completing the program in North Carolina. Data collection involved an additional three questionnaires administered by VMOs: the Swine Health Report (SHR), the Facilities and Feed Report (FFR), and the Ending Inventory and Economics Report (EIER). Data entry, editing, and validation was accomplished at the NC area office of the US Department of Agriculture (USDA) using R-Base programs created by NAHMS staff (NAHMS, 1989c). Data were collected from December 1989 to March 1991.

2.2. North Carolina Swine Survey

Stratified random sampling was used to select 200 producers from a list frame provided by North Carolina Department of Agriculture (NCDA) obtained from the pseudorabies eradication program. All swine producers in the State were required by law to be tested annually, thereby contributing to the list frame. Farms were eligible if they had at least five sows and were not participants in the NSS.

Table 1 lists the NSS sections evaluated in the NCSS. Due to the length of the four questionnaires used in the NSS, several sections were omitted in coming up with a single data collection instrument to be used in the NCSS. Sections used in the NCSS questionnaire were pared down by dropping certain questions. An attempt was made to retain a representative sample of the different types of question structures used in the NSS and to keep the original wording and question order intact. The four NSS questionnaires were combined in this manner in order to minimize questionnaire effect on point estimates obtained in the NCSS. Selected questions from the EIER were also used in the NCSS, however some questions structured as tables were broken down into shorter questions. These questions were not evaluated for similarity since question structure and wording had been changed between the two studies.

Implementation of the NCSS was similar to the implementation of the NSS in North Carolina. Interviews were conducted according to the guidelines laid out in the VMO handbook (NAHMS, 1989b). Data entry, editing, and validation were performed using a modified version of R-Base programs used in the NSS.

Table 1
Data collected in the National Swine Survey

Visit	Collection tool	Questionnaire sections compared
National Agricultural Statistical Service	General Swine Farm Report	Section 2: Management Section 7: Breeding stock management
First interview	Swine Health Report	Section 1: Biosecurity Section 2: Disease problems in the last year Section 3: Vaccination practices Section 4: Preventive practices Section 6: Water collection
Second interview	Facilities and Feed Report	Section 1: Farrowing and preweaning facilities Section 2: Monitored farrowing facilities Section 5: Breeding facilities Section 6: Gestation facilities Section 7: Feed data sheets
Third interview	Ending Inventory and Economic Report	

Data were collected from 140 North Carolina producers from July 1990 to June 1991.

At the conclusion of the two respective studies, datasets were transferred to Statistical Analysis Systems Institute Inc. The NCNSS was merged with the NCSS data to form the final comparison dataset on a SUN workstation at the College of Veterinary Medicine's Population Medicine computing center. Primary analysis of this dataset was performed using SAS Version 6.07 (SAS Institute Inc., 1990) and Microsoft Excel 4.0 (Microsoft, 1992).

2.3. Analysis

The primary hypothesis tested in this study was that there is no significant difference between response estimates obtained from the two study populations. Applying an identical measurement process to the same population, i.e. North Carolina swine farms, is expected to produce equivalent point estimates. The degree to which this is true reflects the reliability of the measurement process used in the NSS. Two approaches were taken to evaluate differences between point estimates.

Data collected from the SHR were predominantly qualitative in nature with mutually exclusive categories. A smaller number of variables were continuous. The FFR collected data which also were predominantly qualitative but with response categories that were not mutually exclusive. Section 2 of the GSFR on Management consisted of qualitative data (mutually exclusive response categories) while Section 7, on Breeding and Replacements, was predominantly quantitative, consisting of both continuous and discrete type data. Continuous

data also were categorized, following the lead of NAHMS in the Descriptive Report. Two approaches were taken to evaluate differences between point estimates.

First, the proportion of farms in a particular response category was calculated for each study. Differences between those proportions were calculated (NCNSS−NCSS) and used as the primary statistics summarized in this study. Point estimates were considered discrepant if there existed a greater than 15% absolute difference between the two proportions. A benchmark value being arbitrary, 15% was chosen. It was felt by the authors that for most management practices being evaluated, one would want to know the proportion of farms using that practice within 15%.

For Sections 3 and 4 of the SHR, where discrepancies appeared to be excessive without an apparent explanation, e.g. misclassification, farm size was suspected to be a confounder. To control for farm size, point estimates were calculated for three strata (<99 sows, 100–299 sows, 300+ sows) and then assessed for similarity.

Secondly, the chi-square statistic was used to test whether the proportions for the two populations were equal (Fleiss, 1981). A plot of the chi-square statistics should reflect the chi-square distribution if differences in proportions are only due to chance. Therefore, the chi-square statistics for equivalent proportions for each response category were plotted by questionnaire section.

2.4. Assumptions

It was assumed that the two sampling frames used were consistent in their definition of a hog farm and covered the same population, i.e. North Carolina farms during 1990 with ten or more hogs. Secondly, it was assumed that there was no effect of questionnaire administration between the two studies, i.e. as four separate questionnaires versus one single questionnaire. It was assumed that if the two samples produced similar point estimates, that both studies measured the true population parameters accurately, and more important, that the NSS is reliable.

3. Results

Of the 200 producers selected, 162 were eligible to participate. Of those eligible, 139 (85.8%) completed the survey. The median number of breeding females per farm for the NCNSS was 137 (range 2–1569) with 37.5% of farms having fewer than 100 sows. For the NCSS, the median number of sows was 45 (range 2–1715) with 59.5% having fewer than 100 sows. The percent of farms with more than 300 sows was 25.0% and 20.9%, respectively, for the two studies. The percent of farms considered farrow to finish was 72.5% and 51.0% for the NCNSS and NCSS, respectively. Both samples were equivalent in regards to the day-to-day decision maker being an independent operator (65.5% versus 69.9%, respectively) and independent producers marketing directly (77.5% versus 77.7%).

Detailed descriptive statistics from the NCSS and the NCNSS are available on request.

3.1. Point estimate differences between NC/NSS and NCSS

A frequency histogram of the distribution of absolute differences between point estimates was created for each section of the NSS questionnaires that was evaluated (Fig. 1). A summary of the mean and median difference, range, and percent of estimates within 15% is given in Table 2. Typically, 25–30% of the estimates were considered discrepant with the greatest number occurring in Sections 3 and 4 of the SHR, covering vaccination and preventive practices.

For Section 1a of the SHR, only 55% of the point estimate differences for the biosecurity questions relating to people and hog movement were within 15%.

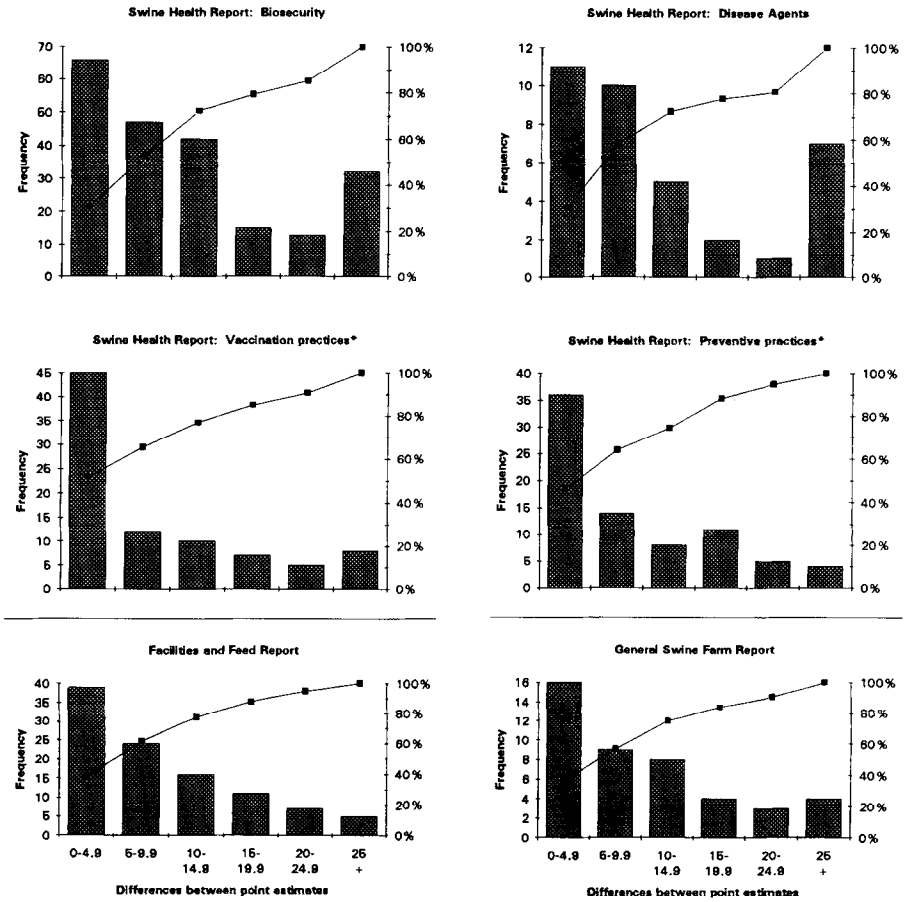

Fig. 1. Distribution of point estimate differences by questionnaire section comparing the North Carolina Swine Survey (NCSS) and the National Swine Survey (NSS).

Table 2
Descriptive statistics for point estimate differences between North Carolina portion of the National Swine Survey (NCNSS) and the North Carolina Swine Survey (NCSS) by questionnaire section (1990, North Carolina, USA)

Section	Median	Min	Max	Proportion <15%
Swine Health Report–Section 1	1.7	−66.3	62.8	72.9
Section 1a	3.8	−66.3	62.8	55.4
Section 1b	2.4	−26.8	25.5	80.7
Section 1c	−0.2	−14.9	16.9	96.7
Swine Health Report–Section 2	7.6	0.3	70.2	72.2
Swine Health Report–Sections 3, 4	6.8	−7.8	42.0	68.4
Section 3	6.6	−0.8	26.7	69.0
Section 4	7.2	−7.8	42.0	68.0
Swine Health Report–Section 6	−1.5	−5.6	4.6	100.0
Facilities and Feed Report	−1.6	−35.0	25.0	77.5
Section 2	−1.6	−25.4	22.0	76.2
Sections 5 and 6	−2.2	−35.0	25.0	76.2
Section 7	−0.9	−22.7	23.9	82.4
General Swine Farm Report	−0.15	−29.4	26.9	75.0
Section 1	−0.7	−26.0	14.7	85.7
Section 7	−0.15	−29.4	26.9	70.0

Table 3
Descriptive statistics for point estimate differences for Sections 3 and 4 of the Swine Health Report by farm size (number of breeding females)

Section	Farm Size (no. sows)	Median	Min	Max	Proportion <15%
Section 3	Overall	0.0	−27.6	45.5	77.0
	<100	6.7	−3.6	45.5	58.6
	100–299	2.85	−9.8	19.8	93.1
	300+	−3.45	−27.6	16.6	79.3
Section 4[a]	Overall	0.0	−22.9	36.9	74.4
	<100	5.1	−18.4	36.9	69.2
	100–299	0.0	−22.9	30.8	73.1
	300+	0.0	−17.6	23.1	80.8
Section 4[b]	Overall	0.3	−38.3	65.6	66.0
	<100	8.9	−18.4	48.5	60.0
	100–299	3.3	−22.9	65.6	62.0
	300+	−3.4	−38.3	23.1	76.0

[a]Questions 1–3 of Section 4.
[b]Questions 1–4 of Section 4.

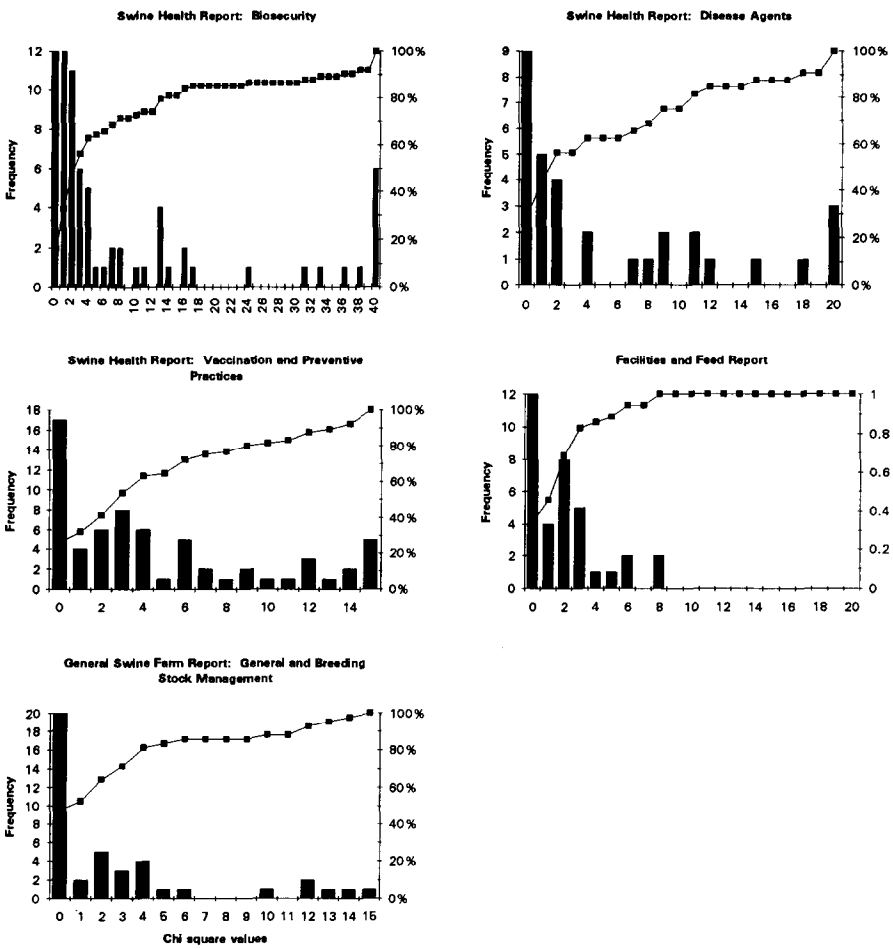

Fig. 2. Distribution of chi-square values by questionnaire section for differences between point estimates from the North Carolina Swine Survey (NCSS) and the National Swine Survey (NSS).

However, for the rest of Section 1, biosecurity questions relating to other animals or rodents on the farm (80% within 15%) and geographic factors (95% within 15%) were much more similar. Looking at the similarity of point estimates between the NCNSS and NCSS for Section 2 (Disease agents) showed that 72% of the proportions evaluated were within 15% of each other. The median difference for this section was 7.6 (highest in the study). Differences in point estimates for Sections 3 and 4 (Vaccination and preventive practices) showed 68% to be within 15%, with a median difference of 6.8. Table 3 gives the mean and median difference, range, and percent of estimates within 15% for these two sections controlling for farm size (number of breeding females). Improvement in the median difference between point estimates for the two surveys is dramatic, from 6.6 and 7.2 to 0.

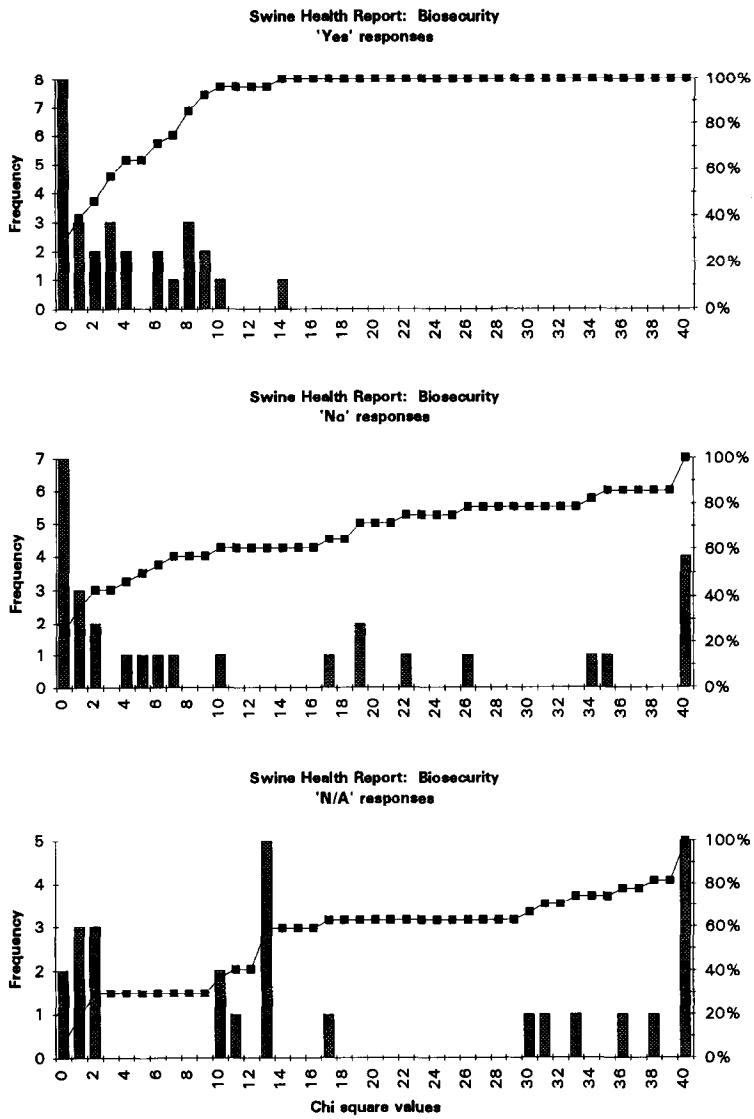

Fig. 3. Distribution of chi-square values by response type for differences between point estimates from the North Carolina Swine Survey (NCSS) and the National Swine Survey (NSS).

Tabulation of point estimate differences for the FFR showed 77% to be within 15% of each other. The median difference was −1.55%, indicating that there was no consistent under- or over-estimation by one study relative to the other. Questions from Sections 1 and 2 concerning the farrowing house indicated that almost 76% were within 15% of each other, with a median difference of −1.6. Sections 5 and 6 (Breeding and gestation facilities) showed similar agreement with 76%

being within 15% and a median difference of −2.2. Besides questions regarding water collection, the feed data sheets produced the most similar point estimates with 82% within 15% of each other and a median difference of −0.9.

For the NCSS, questions from the GSFR were not added until after the initiation of the survey. Therefore the number of farms answering questions relating to general farm management and breeding and replacements was 102 of 139 farms. For this questionnaire 75% of the estimates had less than a 15% difference. The median difference between point estimates is −0.15.

3.2. Chi-square analysis

Chi-square values for point estimates from the two studies were also calculated and plotted to ascertain their distribution (Fig. 2). All sections from the SHR revealed that a fair amount of the chi-square statistics were significantly high (for df=1). A plot of the chi-square statistics for the FFR and GSFR reveal the expected chi-square distribution which is consistent with differences being due only to sampling error. In separating out the chi-square statistics from Section 1 of the SHR into the three response categories (Yes, No, and Not applicable) it is evident that the 'No' and 'N/A' response categories did not show an expected chi-square distribution, while the graph for 'Yes' response category did (Fig. 3). For the 'Yes' response category, 64.3% of the chi-square values were non-significant. For the 'No' and 'N/A' categories, 46.4% and 29.6% of the chi-square values were non-significant.

4. Discussion

A critical assumption underlying this investigation is that both studies sampled identical populations. Although the frame used for the NCSS was not as complete as the NASS frame, there is little reason to suspect a non-coverage bias in either of the two frames. For the NSS, NASS has been developing and maintaining frames for many years. The sampling frame used for the NCSS was developed in conjunction with the Pseudorabies virus (PRV) disease eradication program standards which require testing and identification of all swine farms in North Carolina.

In regards to non-response, the NCSS experienced a much higher response rate (85%) than the NCNSS (53%). This minimizes the likelihood of non-response bias in the NCSS. For the NSS, previous analysis comparing non-respondents and respondents failed to show distinct differences that would lead one to suspect non-response bias (NAHMS, 1992). Finally, differences will arise due to the fact that both studies took a sample of the population; therefore differences due to random sampling will also exist. Effects of these errors of non-observation (non-coverage, non-response, sampling) were not evaluated as part of this study. However, their effect is assumed to be minimal as several supplementary findings concerning the NSS support such a conclusion (NAHMS, 1992).

Questionnaire effects due to administering NCNSS over three separate visits

versus the NCSS which was administered in a single visit were not evaluated. It is assumed that such effects were present but had a minimal impact on point estimates.

While acknowledging that the swine industry is dynamic, there is evidence that the same population was sampled in both surveys. Many descriptors of the samples, independent of interviewer effects, were nearly identical, with the notable exception of farm size. The percent of sampled farms considered 'Inaccessible' (those not able to be reached by phone or mail) for the NCNSS and the NCSS was 10.2% and 9.5%, respectively. The percent of sampled farms 'Ineligible' was 11.1% and 9.5%, respectively. Considerable overlap in the timing of the two studies existed with over 50% of the interviews for the NCSS conducted during the same time period as the NSS. However, the two samples differed considerably in regards to farm size. Since farm size is associated with a great many management factors, this difference could contribute to many of the differences noted between the two studies.

Four sections of the SHR were evaluated for reliability: Section 1 — Biosecurity, Section 2 — Disease Agents, and Sections 3 and 4 — Vaccination and Preventive Practices. Differences between the two studies in the Biosecurity section of the SHR were related to those initial questions dealing with the movement of hogs and people. As pointed out in Fig. 3, the proportion of farms answering 'Yes' were similar between the two studies. Discrepancies were confined to 'No' and 'N/A' response categories. An additional study showed that a large number of interviewers miscoded responses which were to be categorized as 'No' or 'N/A' (Bush et al., 1993). For user's desiring to know the percent of farms actually implementing a biosecurity practice (response 'yes'), the NSS data will prove to be reliable. Those interested in percent farms responding 'N/A' or 'No' will find the data less dependable. From a practical standpoint, most applications of the data will fall into the former category.

While discrepancies in the Biosecurity section (Section 1) of the SHR were attributed to an interviewer effect, it was speculated that discrepancies in the Disease Agents section (Section 2) were most likely attributed to a questionnaire or respondent effect. This section is made up of 'attitudinal questions' unlike most of the survey which consists of 'factual questions'. Therefore, it can be expected that the subjective responses generated by this section would produce less precise estimates (Groves, 1989). The majority of discrepancies existed for disease problems occurring frequently which is consistent with the statistical quality of proportions (largest variance where $P=0.5$). Even though 72.2% of the point estimates were within 15%, this section produced the highest median difference between the two studies. The subjectivity of the questions is accentuated by the subjectivity of producer observations, which has been documented by others (Vaillancourt et al., 1990; Morrow et al., 1992). The following mechanism is proposed: because of the novelty of the situation, disease problems which are less common are more clear-cut and more consistently identified by respondents as a problem. The more common diseases are open to speculation as to whether or

not they are a problem. What one producer considers to be a disease problem, may be just a part of another producer's daily routine. Consequently, the results obtained are influenced by the interviewer–respondent–environment interaction and are unlikely to be an unbiased estimate of the true underlying 'prevalence' or level of problem experienced on the farm. Mechanisms for this are discussed in Cowen et al. (1992).

Analysis of the sections on vaccination and preventive practices (Sections 3 and 4), illustrate the need for controlling confounders when assessing the reliability of point estimates. Crude comparisons suggested there were discrepancies in this section. However, after stratifying on farm size, good agreement was achieved except for the small farms category. Sampling error is a likely source of part of this variation; however, it is hypothesized that an interviewer effect is also at work. An example of how this type of bias would manifest itself would be in the interviewer's interpretation of 'routine use' of a vaccination or preventive practice. When producers indicate a given practice is implemented as needed, individual interviewers will interpret and code this answer differently. One may think it important to capture information stating that the farm does treat for mange/lice; however, a second may determine that 'as needed' is not routine and therefore not to be recorded as a preventive practice used on this farm. This variation, with the percent of interviewers coding each way, has been documented (Bush et al., 1993).

Evaluation of point estimates from the FFR showed good agreement with small median differences between the two studies (Table 2). Variables from the feed data sheet showed especially good agreement. This was true for continuous data in general throughout the study. It is thought that the high similarity of this section can be attributed to the simple, straightforward wording of unambiguous questions, which was not necessarily the case for the SHR. Another consideration is that the FFR was administered on the second visit, a month after the first visit. The respondents experience with the study and previous contact with the VMO were likely to lead to improved reporting between interviewer and respondent which may in turn produce higher quality responses.

5. Conclusion

Although it is obvious that the two surveys contained many differences in their estimates of management, health and facilities for the North Carolina swine population, the basic picture which emerged is similar. For eight of the ten sections from the NAHMS/NSS that were evaluated, more than 70% of the point estimates compared were similar to estimates from the NCSS. The median difference between the two studies exceeded 2.5 for only three of the ten sections. Thus, there is broad agreement in these two randomly sampled surveys of the North Carolina swine population. This supports a conclusion that most sections of the NSS appear to be quite reliable. However, specific groups of questions suffer from misclassification bias, a general lack of precision, or are affected by sources of non-sampling errors.

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